Transcutaneous Functional Electrical Stimulation of a Human Arm

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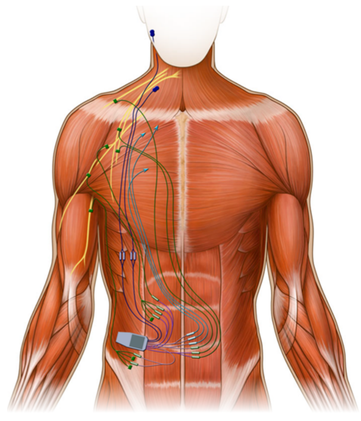
Motivation

Patients with high spinal cord injuries are unable to perform simple, everyday tasks on their own. Functional electrical stimulation is a means for restoring function to muscles and shows promise for aiding people with paralysis. There are various ways to deliver electrical stimulation, two of which are via an implanted neuroprosthesis device or using a transcutaneous device.

Implanted devices, such as the neuroprosthesis pictured below, are highly invasive, expensive, and patient-specific. Due to these limitations, performing research using an implanted neuroprosthesis device is often limited to a small number of patients. On the other hand, transcutaneous devices deliver electrical stimulation via electrodes applied to the surface of the skin and can be used on paralyzed patients as well as healthy individuals.

Due to the benefits of using transcutaneous devices as opposed to implanted devices, it is valuable to prove that transcutaneous devices can produce functional motion of a human arm.



Implanted Neuroprosthesis

Methods

Device Setup:

Stimulation is delivered to the muscle via electrodes pairs. These electrode pairs are connected to a UECU stim board that is controlled using a computer interface. The intensity of stimulation can be changed by altering the pulse width of the delivered electrical pulse. The pulse width is altered manually using a graphical user interface consisting of a slider for each stim board channel. The slider is able to adjust the pulse width between 0 μsec and 20 μsec in 1 μsec intervals. The stim board has eight channels, therefore up to eight electrode pairs can be used and up to eight muscles can be targeted at a time.

Methods

Experiment Setup:

One electrode pair is used per target muscle. The two electrode pads in a pair are placed on either end of the targeted muscle mass. Various target muscles were tested to determine the feasibility of producing functional arm motion via surface stimulation. Rotation about the shoulder and elbow joints was considered functional motion, while motion on the hand and wrist was considered less significant.

Results

A set of eight target muscles was determined to respond predictably to surface stimulation while producing functional motion in the arm.

- Pectoralis major
- Brachialis
- Brachioradialis
- Biceps
- Triceps
- Trapezius
- Anterior deltoid
- Lateral deltoid

Limitations

- With the current stim board, only eight electrode pairs can be used at one time, limiting the complexity of motion that can be obtained.
- The success of surface stimulation is greatly influenced by the proximity of the target muscles to the skin, therefore successful stimulation is limited to muscles that are close to the surface and are unobstructed by bones.
- Pain threshold varies from person to person. A low pain threshold can prevent the delivery of stimulation intense enough to produce motion.

Future Work

Now that the feasibility of producing functional motion in the arm using surface stimulation has been proven, the next step is to implement a transcutaneous device in place of an implanted device for future studies. The next goal is to recreate the controllers previously developed for use on a human leg. The purpose of this controller is to prove that functional electrical stimulation of the arm can be made more accurate and reliable by introducing restraints to the environment such as damping.

Electrode Placement